

AD-A246 252



DOCUMENTATION PAGE

Form Approved

OMB No. 0704-0188

It is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including this burden estimate, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Road, to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

2. REPORT DATE Aug. 15, 91		3. REPORT TYPE AND DATES COVERED FINAL 04/01/87 - 6/30/91	
4. TITLE AND SUBTITLE LABORATORY STUDIES OF ATOMIC COLLISION PROCESSES		5. FUNDING NUMBERS DAAL 03-87-K-0048	
6. AUTHOR(S) Rainer Johnsen		8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Pittsburgh . Pittsburgh, PA 15260			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Office P. O. Box 12211 Research Triangle Park, NC 27709-2211		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This research program has dealt with atomic collision processes of interest for models of natural or man-made plasmas, such as electrical discharge devices, gas lasers, and atmospheric plasmas. Specific topics have included: (A) Electron-ion recombination of NO^+ , O_4^+ , and N_4^+ ions, preparation of data compilations on electron-ion recombination, (B) Experimental measurements of rates of neutral-stabilized electron-ion recombination, (C) Experimental measurements of recombination of positive with negative ions, (D) Experimental and theoretical work on ion-atom and ion-molecule elastic and reactive collisions, and laser-induced charge-transfer reactions.			
14. SUBJECT TERMS Electron-ion recombination, Plasma-afterglows, Ion-ion recombination, Ion-atom association, Drift-tube techniques, Photon-induced charge transfer,		15. NUMBER OF PAGES	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL

**LABORATORY STUDIES OF ATOMIC COLLISION
PROCESSES**

Final Technical Report

by

Rainer Johnsen

Aug. 15, 91

U.S. ARMY RESEARCH OFFICE

Research Agreement No. DAAL03-87-K-0048

**University of Pittsburgh, Department of Physics and Astronomy,
Pittsburgh, PA 15260**

Approved for Public Release: Distribution Unlimited

**THE VIEWS, OPINIONS, AND/OR FINDINGS CONTAINED IN THIS REPORT ARE
THOSE OF THE AUTHOR AND SHOULD NOT BE CONSTRUED AS AN OFFICIAL
DEPARTMENT OF THE ARMY POSITION, POLICY, OR DECISION, UNLESS SO
DESIGNATED BY OTHER DOCUMENTATION.**

92 2 12 112

92-03641



I. Scope of the Research Program

The research program carried out under Research Agreement No. DAAL03-87-K-0048 has dealt with atomic collision processes of interest for models of natural or man-made plasmas, such as electrical discharge devices, gas lasers, and atmospheric plasmas. Specific topics have included plasma deionization processes, in particular electron-ion and ion-ion recombination processes and ion-atom interactions.

Several distinct experimental techniques were used in this work, in particular afterglows of microwave-generated or photoionized plasmas, and ion drift tube methods.

Technical details and results of this work have been published in scientific journals or conference proceedings. References to published work are given in the sections on specific research topics.

II. Specific Research Topics

A. Dissociative recombination of electrons with molecular ions.

1. Our earlier work on recombination of NO^+ ions as a function of electron temperature was published during this report period. (Ref.1)
2. Our earlier work on recombination of O_4^+ ions as a function of electron temperature was published during this report period. (Ref.2)
3. A data compilation and critical review of electron-ion recombination data obtained by the microwave afterglow method was published. (Ref.3)
4. Experimental work was carried out on molecular band emissions resulting from products of N_4^+ recombination. The results have just been submitted for publication. (Ref.4)

B. Neutral stabilized electron-ion recombination

1. Experimental work was carried out on high-pressure recombination in helium gas to test theories of neutral-stabilized electron-ion recombination. This work has been published. (Ref.5)
2. A search for effects of electron localization on electron-ion recombination in cryogenic helium plasmas at a temperature of 4K has been carried out. This work is still in progress.

C. Recombination of positive with negative ions.

1. Subsequent to the development of suitable experimental methods, ion-ion recombination of molecular ions was studied in helium and argon gas in order to test theories on such processes. The results have been published. (Ref.6)
2. The recombination of Xe^+ with F^- ions and excimer emissions from the XeF^* product were investigated. The results have been published. (Ref.7)

D. Ion-atom and ion-molecule reactions

1. As a test of ion transport theory, the mobility of He^+ ions in helium was measured and the results were compared to theoretical calculations by L.A. Viehland using interaction potentials obtained from spectroscopic data. This work was published jointly with L.A. Viehland. (Ref.8)

2. A semi-empirical theory on ion-atom association reactions was developed and compared to experimental data on such reactions. The goal of this work was to provide a simple estimating formula that could be used to obtain rate coefficients for plasma models. Published (Ref.9)

3. Ion-molecule association reactions in HCN were studied experimentally. Published (Ref.10)

4. Very extensive work was performed to find evidence for laser-induced charge transfer of Ne^+ ions with He. It appears that cross sections for laser induced charge transfer are far smaller that had been expected from previous work. This work is still in progress.

Participating personnel:

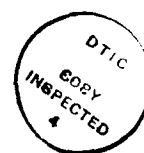
R. Johnsen

B.K. Chatterjee (PhD 1988)

H.S. Lee (PhD 1990)

R. Tosh

Y.S. Cao



Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Publications during period from 04/01/87 to 6/30/91
(Reprints or preprints are available on request)

Journal articles:

1. "Electron temperature dependence of the recombination of electrons with NO^+ ions", J.L. Dulaney, M.A. Biondi, and R. Johnsen. Phys. Rev. A 36, 1342 (1987)
2. "Electron temperature dependence of the recombination of electrons with O_4^+ ions", J.L. Dulaney, M.A. Biondi, and R. Johnsen. Phys. Rev. A 37, 2539 (1988)
3. "Microwave afterglow measurements of the dissociative recombination of molecular ions with electrons", R. Johnsen, Int. J. Mass Spectr. and Ion Proc. 81, 67 (1987)
4. "Recombination of N_4^+ ions with electrons", Y.S. Cao and R. Johnsen, submitted to J. Chem. Phys. in June 1991
5. "Neutral stabilized recombination in ambient helium gas", Y.S. Cao and R. Johnsen, J. Chem. Phys. 94, 5443 (1991)
6. "Ion-ion recombination studies in ambient helium and argon at atmospheric densities", H.S. Lee and R. Johnsen, J. Chem. Phys. 90, 6328 (1989)
7. "Recombination of Xe^+ with F^- ions in ambient helium", H.S. Lee and R. Johnsen, J. Chem. Phys. 93, 4686 (1990)
8. "Mobility of helium ions in neon: Comparison of theory and experiment", R. Johnsen, R. Tosh, and L.A. Viehland, J. Chem. Phys. 92, 7264 (1990)
9. "An estimating formula for ion-atom association rates in gases", B.K. Chatterjee and R. Johnsen, J. Chem. Phys. 93, 5681 (1990)
10. "Clustering reactions of H_2CN^+ ions with HCN ", B.K. Chatterjee and R. Johnsen, J. Chem. Phys. 87, 2399 (1987)

Book chapters:

11. "Electron-ion, ion-ion, and ion-neutral interactions", R. Johnsen, in "Nonequilibrium effects in ion and electron transport", Edited by J. W. Gallagher, D.F. Hudson, E.E. Kunhardt, and R.J. van Brunt, (Plenum Press, New York and London, 1990)
12. "Recombination measurements in microwave plasma afterglows", R. Johnsen, in "Dissociative recombination: Theory, experiment, and applications", Edited by J.B. A. Mitchell, and S. L. Guberman (Word Scientific 1989)